1944

Results of experiments with rice in Louisiana

John Mitchell Jenkins

LOUISIANA BULLETIN NO. 384 AUGUST, 1944

Results Of Experiments With Rice In Louisiana

By

J. MITCHELL JENKINS AND JENKIN W. JONES

LOUISIANA STATE UNIVERSITY

AND

AGRICULTURAL AND MECHANICAL COLLEGE

AGRICULTURAL EXPERIMENT STATIONS

W. G. TAGGART, *Director*

CONTENTS

Results Of Experiments With Rice In Louisiana [1]

By

J. MITCHELL JENKINS AND JENKIN W. JONES [2]

INTRODUCTION

Rice is the staple food of about half the world's population. Recent developments affecting rice supplies make it highly desirable to maintain and, if possible, increase acre yields in order to help meet the requirements of the Allied Nations for this important cereal. Total production can be increased either by (1) producing higher yields per acre, (2) increasing the acreage sown, or (3) a combination of these two methods. The first method is most logical, for higher yields may be produced on the present acreage without much, if any, extension of present irrigation systems or increase in farm equipment, whereas, a marked increase in acreage would require considerable expansion in irrigation facilities, and much additional farm machinery which is scarce. The purpose of this bulletin is to report results obtained at the Rice Experiment Station, Crowley, La., and to indicate ways in which the acre yields of rice can be maintained and even increased.

The commercial rice crop of the United States is produced in Louisiana, Texas, Arkansas, and California. In the 10-year period (1930-39), the average acreage and production for the United States was 943,000 acres and 45,712,000 bushels, or an average yield of 48.4 bushels per acre. In the same 10-year period, 48.3 and 40.6 percent, respectively, of the total acreage and production were in Louisiana, 21.7 and 23.3 percent in Texas, 17.5 and 20.4 percent in Arkansas, and 12.5 and 17.5 percent in California. There were 1,500,000 acres harvested in 1943 and total production was 70,025,000 bushels. This was the largest crop on record. In Louisiana, rice is the second most important farm crop, ranking next to cotton. The principal area of production is in the southwestern part of the State, in Acadia, Vermilion, Jefferson Davis, and Calcasieu parishes.

---

[1] Submitted for publication August, 1944. The yields reported in this bulletin were obtained in cooperative investigations between the Louisiana Agricultural Experiment Station and the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture.

[2] Associate Agronomist, Division of Cereal Crops and Diseases, and Superintendent, Rice Experiment Station, Crowley, La., and Senior Agronomist, Division of Cereal Crops and Diseases.

SOIL AND CLIMATE

Soil

The soil at the Rice Experiment Station, Crowley, La., is brown or ash gray in color, and is classified as Crowley silt loam. The loam extends to a depth of 10 to 25 inches, with an average depth of about 16 inches. The subsoil consists of a mottled blue and yellow clay and both the surface and subsoil are rather impervious to water. Crowley silt loam is the predominating type of soil in the principal rice-producing section of southwestern Louisiana, and the results obtained at the Station are believed to be applicable in general to adjacent areas in which rice is grown.

Temperature

The winters in southwestern Louisiana are comparatively cool, with some freezing weather. The springs are warm, and in summer the average mean temperatures ranges from 81° to 82°F., and in the fall from 60° to 78°F. The warmest months are June, July, and August, with average maximum temperatures of 89°, 90°, and 91°F. respectively. The highest temperatures recorded at the Station during the 33-year period, 1910-1942, were 103°F. on June 27, 1930, and on August 10, 1935, and the lowest temperature was 9°F. on January 12, 1918.

Precipitation

The average annual precipitation for the 33-year period (1910-42) was 57.40 inches, with an annual range from 30.58 inches in 1924, to 106.64 inches in 1940. During the 33-year period, the months having the highest average precipitation were August 6.32, July 6.17, December 5.79, and January 5.23 inches; those having the least precipitation were October 3.39, April 3.87, and March 3.97 inches. Fortunately, the precipitation is so distributed from March through May, the seeding season, and from August through November, the harvest season, that there is seldom loss from excessive rainfall. An exception to this was August, 1940, during which the precipitation was so high (37.5 inches) as to cause much injury to the rice crop. The crop on the Rice Experiment Station was so irregular that the yield data obtained are not used in this bulletin. The humidity during the growing season is relatively high, being favorable for the development of fungus diseases, which cause some reduction in yield and in the quality of the crop.

Evaporation

The months of highest evaporation are May, June, July, and August. The total 33-year (1910-42) average annual evaporation from a free water surface was 50.89 inches, or 6.52 inches less than the average annual precipitation for the same period. The months of highest evaporation coincide with the period of most active growth and transpiration of the rice crop, and hence, during this period a shortage of fresh irrigation water for an extended period may result in much injury to the crop. The two main hazards to rice production in this area are drought and floods, or excessive rainfall during the harvest period. For more detailed information on climatic conditions at the Rice Experiment Station, see Chambliss and Jenkins (2)[3].

METHODS

In the experiments reported in this bulletin, the rice was grown in rectangular plots varying in size from one-sixtieth to one-tenth of an acre. In a few experiments, duplicate plots, but in most experiments systematically replicated, triplicate, or quadruplicate plots were used. The preparation of the seedbed, the date and rate of seeding, and the time and method of irrigation were the same each year for all plots within a given experiment.

Seedbed preparation consisted of late fall plowing, followed in the spring by disking, harrowing, and dragging to prepare a smooth seedbed except as otherwise indicated. The rice was sown with a grain drill at the rate of approximately 80 pounds per acre, except in one experiment. These, and other cultural practices used are based on results reported by Chambliss and Jenkins (2).

EXPERIMENTAL RESULTS

The investigations herein reported include results of varietal, date of seeding, irrigation, rotation, fertilizer, and pasture experiments. The yields for 1940 are not included because of injury to the crop as a result of the August flood.

Varieties

Thirteen varieties were grown in field plots replicated 3 or 4 times from 1937 to 1942. These may be divided into early, midseason, and late maturing groups. In the early group, Zenith and Early Prolific are medium-grain, and Edith, Lady Wright, and Delitus are long-grain varieties. In the midseason group, Caloro and Acadia are short-grain, Improved Blue Rose and Shoemed medium-grain, and Fortuna and Nira are long-grain varieties. The kernels of Delitus, Rexoro, Nira, and Iola are more slender than those of Edith and Lady Wright. Delitus is a scented rice. Rexoro, Fortuna, Nira, Shoemed, Iola, and Delitus are resistant to Race 1 of the leaf spot fungus (**Cercospora oryzae**), whereas, the other varieties listed are susceptible. The annual and average yields of the 13 varieties are given in Table 1.

---

[3] Numbers in parentheses refer to Literature Cited p. 38.

TABLE 1—ANNUAL AND AVERAGE YIELDS OF RICE VARIETIES GROWN IN FIELD PLOTS, FROM 1937 TO 1942, CROWLEY, LOUISIANA

Group and Variety	C. I. No.	Acre Yields In Bushels						
		1937	1938	1939	1941	1942	4-year Average 1937-41	5-year Average 1937-42
Early group:								
Zenith	7787	45.3	31.7	37.4	37.7	51.0	38.0	40.6
Early Prolific	5883	38.7	25.9	40.5	39.2	41.6	36.1	37.2
Delitus	1206	35.8	23.8	27.4	27.5	——	28.6	——
Edith	2127	34.5	21.1	24.6	25.6	——	26.5	——
Lady Wright	5451	25.8	20.9	28.1	28.6	——	25.9	——
Midseason group:								
Improved Blue Rose	2128	48.6	31.5	46.5	44.4	32.9	42.8	40.8
Fortuna	1344	34.1	36.4	43.4	50.5	36.2	41.1	40.1
Nira	2702	32.1	32.6	52.1	52.9	16.4	42.4	37.2
Acadia	1988	21.2	26.2	43.4	55.3	34.7	36.5	36.2
Shoemed	3625	43.2	26.7	36.5	44.9	27.7	37.8	35.8
Caloro	1561-1	27.4	24.0	39.0	47.3	28.4	34.4	33.2
Late group:								
Rexoro	1779	37.4	39.5	54.6	58.4	49.8	47.5	47.9
Iola	4559	35.9	35.3	44.6	37.8	40.9	38.4	38.9

The 4-year average yield of all varieties listed in the early group was 31 bushels, in the midseason group 39 bushels, and in the late group 43 bushels per acre. The highest yields were secured from Rexoro and Improved Blue Rose both in the late group. In the early group, Zenith was somewhat better than Early Prolific, and both of these were also considerably more productive than Delitus, Edith, and Lady Wright, which ranked in the order listed.

In the midseason group, Improved Blue Rose and Fortuna yielded appreciably higher than Acadia, Shoemed, and Caloro. Nira produced an unusually low yield in 1942, which brought its 5-year average materially below that of Improved Blue Rose and Fortuna. Its average for other years is substantially equal to that of Improved Blue Rose. In the late group, Rexoro yielded much higher than Iola.

These results and others previously reported by Chambliss and Jenkins (3) and by Jones, et al., (7), indicate that Zenith and Early Prolific in the early group, Improved Blue Rose, Fortuna, Nira, and Acadia in the midseason group, and Rexoro in the late group, are well adapted for growing in Louisiana. These include varieties of different grain types and time of maturity. Among them, growers should be able to choose varieties so as to distribute the harvest over a relatively long period, and to benefit by having rice of different grain types to market each year.

Dates of Seeding

On Dry Land

Four rice varieties were seeded in duplicate plots with a grain drill at intervals of about 2 weeks from March 15 to June 15 during the 6-year period 1933 to 1938, and two additional varieties were included during the 5-year period 1934 to 1938. There were a few unavoidable omissions in the June seedings for both periods. The annual and average yields, dates of maturity, and number of days from seeding to maturity are shown in Table 2.

The highest average yields (6 years) for Fortuna, Rexoro, Blue Rose, and Caloro were from seeding about April 1, and for Early Prolific and Nira (5 years) from seeding May 15.

No variety yielded best on the average from seeding at the earliest date, about March 15, nor from the latest seeding on June 15. The yearly variations are very large, however, suggesting that in some seasons good yields may be expected even though seeding is somewhat earlier or later than the best average dates.

Also, some varieties are less sensitive than others to variation in date of seeding. Thus, relatively good yields were secured from Fortuna and Nira for all dates of seeding while those from the June 15 seeding of Blue Rose and Caloro were very low. Early Prolific seems to be especially sensitive to very early seeding since it produced low yields every year from seeding around the middle of March, as compared with around April 1 or April 15, and generally low as compared with all dates of seeding up to and including the middle of May. Yet Early Prolific is sown on commercial fields before the other varieties.

The last column of Table 2 gives the average dates of maturity and the number of days from seeding to maturity. When seeded on or near April 1, Early Prolific, Fortuna, Nira, and Caloro mature early and approximately in the order named, and Blue Rose and Rexoro two to three weeks later. When seeded about May 15, however, Blue Rose ripens about the same time as Fortuna and Nira, and Caloro ripens even earlier than Early Prolific. This is because Blue Rose and Caloro are more sensitive than the other varieties to length of day, and hence, tend to head and ripen more rapidly as the days become shorter. Growers who wish to extend the harvest season over a long period should take this relation into account. They would gain very little, for example, by late seeding of Blue Rose or Caloro without seeding so late as to materially reduce yields; whereas, the harvest period could be considerably lengthened by seeding the other varieties on successive dates. It should be noted, however, that Nira, Fortuna, and Rexoro may not mature before frost if seeded too late. This means that when, for any reason, it is desirable to seed very late in the spring, it is safer to use

TABLE 2—ANNUAL AND AVERAGE YIELDS OF SIX VARIETIES OF RICE GROWN IN DATE-OF-SEEDING EXPERIMENTS, FROM 1933-1938, AT CROWLEY, LA.

Variety	Average Date of Seeding	Acre Yields in Bushels								Average	
		1933	1934	1935	1936	1937	1938	Average		Date of Maturity	No. Days from Seeding to Maturity
								1933 to 1938	1934 to 1938		
Fortuna	March 17	55.9	35.3	66.7	33.4	45.5	29.4	46.0	42.1	Aug. 27	164
	April 3	53.9	53.6	66.1	39.3	50.5	27.4	48.5	47.4	Sept. 3	152
	April 15	51.2	39.4	52.4	37.0	39.3	23.8	40.5	38.4	Sept. 12	149
	May 3	43.2	35.0	69.9	31.1	36.2	21.8	39.6	38.8	Sept. 22	141
	May 17	41.2	37.7	64.9	26.1	22.5	32.1	37.4	36.7	Oct. 3	139
	June 1	46.6	35.0	47.4	26.1	23.1	27.1	33.7	31.7	Oct. 20	141
	June 15	25.3	45.3	34.9	——	25.6	25.1	31.2	——	Oct. 26	133
Rexoro	March 17	42.6	47.7	45.5	34.1	27.4	33.7	38.5	37.7	Sept. 22	189
	April 3	59.2	43.3	88.0	34.7	28.7	29.8	47.3	44.9	Sept. 25	180
	April 15	48.5	36.0	56.8	32.7	28.7	35.4	39.7	37.9	Oct. 7	175
	May 3	50.5	50.2	86.7	35.0	35.6	20.2	46.4	45.5	Oct. 19	169
	May 17	46.6	44.6	73.6	24.8	26.2	27.1	40.5	39.3	Oct. 29	165
	June 1	39.2	43.0	65.5	——	43.0	24.5	43.0	——	Nov. 7	159
	June 15	28.0	37.0	26.8	00.0	21.8	00.0	19.0	——	Nov. 14	152
Blue Rose	March 17	49.2	38.7	31.8	40.3	49.3	36.7	41.0	39.4	Sept. 19	186
	April 3	58.5	32.7	69.9	40.0	53.0	29.1	47.2	44.9	Sept. 22	172
	April 15	31.9	22.8	49.9	28.1	36.2	37.7	34.4	34.9	Sept. 25	163
	May 3	33.9	32.4	82.3	28.1	51.1	27.4	42.6	44.3	Sept. 26	146

	May 17	33.9	32.7	69.9	24.8	42.4	29.8	38.9	39.9	Oct. 3	139
	June 1	31.3	24.5	47.4	18.5	50.5	31.7	34.0	34.5	Oct. 10	131
	June 15	27.9	31.4	46.8	18.8	33.7	17.8	29.4	29.7	Oct. 19	126
Caloro	March 17	53.9	50.3	36.2	23.5	38.7	6.3	34.8	31.0	Sept. 3	170
	April 3	67.2	45.6	75.5	27.1	53.6	24.1	48.8	45.2	Sept. 4	154
	April 15	41.9	36.4	64.9	17.9	42.4	29.8	38.9	38.3	Sept. 7	145
	May 3	39.9	34.3	73.0	14.9	39.9	20.8	37.2	36.6	Sept. 7	127
	May 17	31.9	24.4	68.6	28.8	26.8	18.5	32.2	32.2	Sept. 17	123
	June 1	25.3	24.4	51.8	7.3	37.4	18.2	27.4	27.8	Sept. 21	112
	June 15	35.9	19.5	23.1	4.6	19.3	11.2	19.0	15.5	Sept. 29	106
Early Prolific	March 17	——	19.3	45.5	19.8	32.4	27.1	——	28.9	Aug. 7	143
	April 3	——	26.4	70.5	31.4	45.5	23.8	——	39.5	Aug. 15	134
	April 15	——	30.4	57.4	31.4	39.3	29.4	——	37.6	Aug. 23	130
	May 3	——	36.7	72.4	23.8	48.7	26.1	——	41.5	Sept. 9	129
	May 17	——	28.4	64.2	27.1	34.3	32.4	——	37.3	Sept. 19	124
	June 1	——	26.8	45.5	20.2	38.0	23.8	——	30.9	Sept. 28	119
	June 15	——	28.1	35.6	17.5	29.3	16.5	——	25.4	Oct. 12	119
Nira	March 17	——	35.7	56.8	32.1	28.1	25.8	——	35.7	Aug. 29	165
	April 3	——	41.0	58.6	31.4	47.4	25.4	——	40.8	Sept. 5	155
	April 15	——	31.4	45.5	27.8	51.8	26.8	——	36.7	Sept. 11	149
	May 3	——	43.0	69.2	27.1	39.3	22.8	——	40.3	Sept. 25	145
	May 17	——	45.0	77.3	26.1	33.7	39.7	——	44.4	Oct. 1	143
	June 1	——	37.7	55.5	24.8	42.4	32.1	——	38.5	Oct. 23	144
	June 15	——	——	54.9	——	35.6	10.9	——	33.8	Nov. 3	141

Blue Rose, Early Prolific, or Caloro. Beachell (1) and Jenkins (5) have reported in detail on the reaction of varieties to date of seeding and the effect of length of day and the reader is referred to their reports for additional information.

In Water

During the 4-year period (1934-38), five varieties of rice were sown broadcast in the water in triplicate plots on 3 different dates, about April 1, May 1 and May 15 each year. The stands were so poor in 1935 that yields were not recorded. The annual and average yields are given in Table 3.

TABLE 3—ANNUAL AND AVERAGE YIELDS OF FIVE RICE VARIETIES SOWN BROADCAST IN THE WATER IN A DATE-OF-SEEDING EXPERIMENT, FROM 1934 TO 1938[1], AT CROWLEY, LOUISIANA

Variety	Date of Seeding	Yields Per Acre In Bushels					
		1934	1936	1937	1938	3-year Average 1934-37	4-year Average 1934-38
Fortuna	April 1	23.2	36.0	40.3	—	36.2	—
"	May 1	35.8	20.5	18.8	21.8	25.0	24.2
"	May 15	37.5	9.2	40.3	13.5	29.0	25.1
Average		32.1	21.9	33.1	17.6	29.0	26.2
Rexoro	April 1	29.7	34.6	43.0	—	35.8	—
"	May 1	41.1	14.1	26.9	13.5	27.4	23.9
"	May 15	42.7	4.2	34.9	6.7	27.3	22.1
Average		37.8	17.6	34.9	10.1	30.1	25.2
Blue Rose	April 1	30.2	53.6	44.4	—	42.7	—
"	May 1	37.6	41.7	37.7	21.8	39.0	34.7
"	May 15	37.5	1.2	32.3	26.9	23.7	24.5
Average		35.1	32.2	21.5	24.4	29.6	28.3
Early Prolific	April 1	22.1	24.0	16.1	—	20.7	—
"	May 1	29.1	32.5	16.1	13.5	25.9	22.8
"	May 15	30.2	14.1	32.3	23.6	25.5	25.1
Average		27.1	23.5	21.5	18.5	24.0	22.7
Caloro	April 1	42.6	33.2	45.7	—	40.5	—
"	May 1	47.6	31.8	21.5	35.4	33.6	34.1
"	May 15	49.1	16.9	24.2	23.6	30.1	28.5
Average		46.5	27.3	21.5	29.4	31.8	31.2

In 1938, no stands were obtained from the April 1 seeding due to heavy rains and low temperatures soon after seeding, or before the seedlings were firmly established. The motion of the water covered the seed with soil and, as is usual when this happens with rice seeded in the water, the seed germinated very poorly or not at all.

The highest 3-year (1934, 1936, 1937) average yield for each variety

[1] Failed to get satisfactory stands in 1935.

except Early Prolific was from seeding April 1. For the 4-year period (1934, 1936, 1938), the average yields of Fortuna, Rexoro, and Early Prolific were essentially the same from seeding on May 1 and May 15, but for Blue Rose and Caloro the average yields from the May 1 seeding were much higher than for seeding on May 15.

Blue Rose and Caloro gave much higher yields than Rexoro and Fortuna in this experiment, though as noted above, the latter, when sown with a grain drill on dry land, yields as well or better than Blue Rose, and usually much better than Caloro. This difference in behavior may be due in part to better germination of Blue Rose and Caloro seed when sown in the water, and to better emergence of the seedlings through the water than for the other varieties.

METHODS OF IRRIGATION

Dates of Submergence

Five rice varieties were grown for a 6-year period in an experiment to determine the effect on weed control and on yields of submerging the land 10, 20, 30, and 40 days after the seedlings emerged. The plots were replicated 3 times for each treatment. The annual and average yields are given in Table 4.

TABLE 4—ANNUAL AND AVERAGE YIELDS OF FIVE VARIETIES OF RICE GROWN IN A DATE-OF-SUBMERGENCE EXPERIMENT, FROM 1933 TO 1938, AT CROWLEY, LOUISIANA

Variety	Days Submerged After Seedling Emergence	Yields Per Acre In Bushels						
		1933	1934	1935	1936	1937	1938	6-year Average 1933-38
Fortuna	10	53.3	44.9	37.1	37.1	41.0	33.2	41.1
	20	44.4	50.5	35.3	36.9	42.2	41.0	41.7
	30	43.7	50.9	37.6	35.5	37.1	41.2	41.0
	40	34.4	48.2	29.5	24.4	41.5	36.2	35.7
Rexoro	10	48.8	50.2	33.0	40.1	35.3	35.7	40.5
	20	45.7	52.8	38.7	34.6	36.0	44.0	42.0
	30	42.2	42.4	39.0	27.9	30.6	42.2	37.4
	40	30.6	44.2	37.1	22.4	34.1	39.4	34.6
Blue Rose	10	35.8	36.4	31.1	33.0	33.6	34.6	34.1
	20	32.3	44.9	34.3	34.3	38.4	44.5	38.1
	30	26.6	41.9	34.6	28.6	40.5	42.9	35.8
	40	19.9	39.6	35.3	25.1	45.6	38.7	34.0
Early Prolific	10	20.6	44.0	27.4	35.5	34.1	27.2	31.5
	20	21.3	47.9	33.2	46.1	41.7	41.2	38.6
	30	20.3	40.1	29.3	34.1	43.8	36.6	34.1
	40	16.8	36.4	32.7	25.8	38.0	30.0	30.0
Caloro	10	30.3	44.0	21.0	29.0	33.2	25.1	30.4
	20	24.4	47.2	26.3	36.4	28.6	30.2	32.2
	30	23.1	46.1	20.7	18.7	23.9	26.3	26.4
	40	18.2	44.9	23.7	9.9	25.1	22.6	24.1

The highest 6-year (1933-38) average yields for each variety were obtained on land submerged 20 days after the seedlings had emerged, and for Fortuna, Rexoro, and Caloro the yields from the 10-day submergence ranked second. In most plots, grasses increased and water weeds decreased in proportion to the length of the dry period between seedling emergence and submergence of the land. In other words, early submergence of the land controlled grasses, but favored the growth of water weeds. In the absence of grasses and other semi-aquatic weeds, delaying the submergence until 30 days after seedling emergence and in some years as much as 40 days, caused practically no reduction in yields. The results indicate, that the control of grasses is more important than the control of water weeds, since the highest average yields were in general obtained by early submergence of the land.

Discontinuous vs. Continuous Submergence

The Fortuna variety was grown in plots replicated 3 times during the 6-year period (1934-39) to determine the effect of different methods of irrigation on yields. Four methods were compared, namely: (1) the land was submerged 10 days after seedling emergence and water was held on the land continuously until the plots were drained prior to harvesting; (2) the land was submerged 10 days after seedling emergence, drained 3 weeks later, and after it had dried, was again submerged and water was held until the plots were drained prior to harvesting; (3) the land was submerged at the time the seedlings emerged and the water was allowed to evaporate, and when the land was dry it was again submerged and water was held until just prior to harvesting; and (4) the land was submerged at the time the seedlings emerged, the water was allowed to evaporate, and when the land was dry it was again submerged, drained 4 weeks later, and when dry it was again submerged and water was held until just prior to harvesting. The annual and average yields are shown in Table 5.

TABLE 5—ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE GROWN BY DIFFERENT IRRIGATION METHODS FROM 1934 TO 1939, AT CROWLEY, LOUISIANA

Irrigation Methods	Acre Yields In Bushels						
	1934	1935	1936	1937	1938	1939	6-year Average 1934-39
Number 1	41.9	24.2	28.0	36.4	60.2	41.4	38.7
Number 2	44.4	21.4	31.4	27.8	47.7	25.6	33.1
Number 3	31.4	15.4	28.6	27.5	51.6	38.4	32.1
Number 4	34.8	15.0	33.0	23.9	37.2	32.6	29.4

On the basis of the 6-year average, Method 1 produced 5.6 bushels more than Method 2, which was second best. The results were somewhat variable from year to year, however. The lowest yields were secured by the fourth method. These results indicate that under the conditions existing at Crowley, La., early continuous submergence is, in general, better practice than intermittent drying and submergence of the land.

Holding Water on Uncropped Land

Some growers have expressed the opinion that higher yields may be secured if the land is kept submerged during a portion of the uncropped or resting period. In 1936, an experiment was started to obtain information on this problem. The treatment of the rice stubble, or uncropped land, was as follows: (1) In the fall after the rice was harvested, water was held on the stubble land during the winter, summer, and early fall months. The land was then drained and plowed in late fall and left in the rough until the seedbed was prepared the following spring; (2) water was first put on the stubble land after late fall plowing and held there until March 1, and then the land was allowed to dry for seedbed preparation; and (3) no water was held on the stubble land during any part of the uncropped season. The land was plowed in late fall of the idle year according to the usual practice in the rice area. The Fortuna variety was grown and the plots were replicated 3 times. The annual and average yields are given in Table 6.

TABLE 6—ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE GROWN IN AN EXPERIMENT TO STUDY THE EFFECT ON YIELDS OF HOLDING WATER ON STUBBLE LAND, FROM 1936 TO 1942, AT CROWLEY, LOUISIANA

Treatment	Acre Yields In Bushels							
	1936	1937	1938	1939	1941	1942	6-year Average 1936-42	Average Increase or Decrease
No. 1	22.5	23.0	25.1	27.8	29.1	27.8	25.9	-0.3
No. 2	25.6	28.9	23.1	27.4	31.4	28.6	27.5	1.3
No. 3	18.7	28.9	25.9	26.8	32.6	24.0	26.2	—

The 6-year (1936-42) average yields for the three treatments were essentially the same. The results indicate that the holding of water on uncropped land has neither a beneficial nor a detrimental effect on the yields of rice. In dry periods, however, the holding of water on stubble land is favorable for the growth of native pasture plants.

ROTATION EXPERIMENTS

The rice crop, like other cereals, responds to good cultural methods and rotation systems. In Louisiana, the rice crop is normally grown in alternate years, or once in 3 years, on land that during the resting period is in cultivated fallow or left in stubble pasture for one or two years. Since rice is the main cash crop grown, short-time rotations are generally used by growers. It seemed desirable to determine the relation of rotations to yields of rice and also to compare rotations of different length. Accordingly, some experiments to compare yields in 2-year, 3-year, and 10-year rotations were begun in 1934, and in 4-year rotations in 1936. The Fortuna variety was used in all but the 10-year rotation, and the plots were replicated 3 or 4 times. All except the 10-year rotations were located in the same field.

Two-year Rotations

The 2-year rotations consisted of growing rice in alternate years in rotation with (1) cultivated summer fallow, (2) stubble pasture, (3) Italian rye grass grown on stubble pasture, (4) cotton, (5) *Crotalaria spectabalis*, (6) soybeans, (7) red clover on stubble pasture, and (8) soybeans followed in the fall by bur clover. The ryegrass, red clover, and bur clover were sown on stubble pasture land in the fall. The annual and average yields are given in Table 7.

TABLE 7—ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE GROWN IN 2-YEAR ROTATIONS FROM 1934 TO 1942, AT CROWLEY, LOUISIANA

Year	Acre Yields In Bushels Of Rice In Rotation With:							
	Cultivated Summer Fallow	Stubble Pasture	Italian Ryegrass Grown On Stubble Pasture	Cotton	*Crotalaria Spectabalis*	Soybeans	Stubble Pasture and Red Clover[1]	Soybeans and Bur Clover
1934	67.0	62.4	68.4	70.2	66.3	61.3	58.5	57.4
1935	76.0	61.8	66.1	60.6	65.7	72.4	73.8	76.2
1936	29.2	27.4	30.6	26.7	29.9	33.9	36.4	33.2
1937	36.7	36.7	46.0	24.2	37.1	44.6	43.8	44.6
1938	47.7	51.6	51.0	32.6	44.1	42.7	47.1	43.2
1939	48.7	50.3	54.2	38.5	52.7	51.2	51.2	52.3
1941	37.6	37.7	42.2	27.7	36.6	34.5	40.2	39.9
1942	42.2	43.8	39.2	9.9[2]	39.8	42.3	46.9	38.0
Average	48.1	46.5	49.7	36.3	46.5	47.9	49.7	48.1

[1] Soybeans followed by alsike clover were grown in this rotation in 1934, 1935, and 1936.
[2] Oats substituted for cotton the preceding year.

The highest 8-year average yield (49.7) bushels per acre) was following Italian ryegrass and red clover on stubble pasture. Rice following cultivated fallow, and that following soybeans plus bur clover ranked second. The lowest average yield (36.3 bushels per acre) was following cotton (oats in one year) dusted with calcium arsenate. The low average yield of rice in this rotation, in 1942, was due to the residual effect of calcium arsenate and not to the cotton (or oat) crop. The 8-year average yield of soybeans ranged from 3.4 to 3.9 bushels per acre, and the 7-year average (1933-41) yield of seed cotton was 136.7 pounds per acre. The yields were too low to be profitable.

In addition to the above, Fortuna rice was grown in alternate years on fall-plowed land seeded and not seeded to Italian ryegrass during the 6-year period (1936-42). The 6-year average yields were 40.9 bushels after Italian ryegrass and 42.7 bushels per acre on land without ryegrass. The seeding of ryegrass on plowed land in the fall, therefore, resulted in a small decrease in the average yield of rice.

Three-year Rotations

In the 3-year rotation experiment, rice was grown in rotation with cotton and soybeans each one year. The sequence of crops was rice, cotton, and soybeans. The cotton was dusted with calcium arsenate to control boll weevil, and each treatment was replicated 4 times. The annual and average yields for a 7-year period (1934-41) are shown in Table 8.

TABLE 8—ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE, SEED COTTON, AND SOYBEANS GROWN IN A 3-YEAR ROTATION FROM 1934 TO 1941, AT CROWLEY, LOUISIANA

Year	Acre Yields		
	Seed Cotton Pounds	Soybeans Bushels	Rice Bushels
1934	95	1.9	68.4
1935	151	1.6	54.2
1936	57	2.2	54.3
1937	43	3.3	37.4
1938	7	2.8	28.1
1939	89	2.1	49.9
1941	98	2.5	29.2
Average	77.1	2.3	45.9

The average yield of seed cotton was 77.1 pounds, of soybeans 2.3 bushels, and of rice 45.9 bushels per acre. It is apparent that in this rotation the average yields of cotton and soybeans were too low to be profitable, and the average yield of rice was less than that obtained in the better 2-year rotations in the same field. The lower yield of rice was most likely due to the calcium arsenate used on the cotton. It appears, therefore, that so far as the yield of rice is concerned, it is better practice to grow it in a 2-year rotation, with stubble pasture supplemented with either ryegrass or clover in the fall than in a 3-year rotation of this kind.

Four-year Rotations

The 4-year rotations consisted of two successive rice crops following 2 years in cotton fertilized and in cotton not fertilized, and following 2 years in pasture fertilized, and in pasture not fertilized. The plots were replicated 3 times. On the fertilized cotton and pasture plots a 5-15-5 fertilizer was applied at the rate of 480 pounds per acre. The 5-year (1936-41) average yield of seed cotton on the fertilized plots was 1098 pounds, and on plots not fertilized 77 pounds per acre. The annual and average yields of the first and second crops of rice grown on the fertilized and not fertilized cotton and pasture land in successive years are given in Table 9.

TABLE 9—ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE GROWN IN 4-YEAR ROTATIONS, FROM 1936 TO 1942, AT CROWLEY, LOUISIANA

Preceding Crop and Treatment	Acre Yields In Bushels							
	1936	1937	1938	1939	1941	1942	Average 1936-'42	Average Increase or Decrease*
Cotton:								
Fertilized	50.5	33.6	42.6	36.6	37.6	21.3	37.0	-6.7
Not Fertilized	51.4	31.1	29.1	33.6	38.0	35.1	36.4	-7.3
Average	51.0	32.3	35.8	35.1	37.8	28.2	36.7	
Pasture Stubble:								
Fertilized	43.6	43.3	54.7	44.4	45.6	35.4	44.5	0.8
Not Fertilized	44.6	36.9	47.6	42.9	49.2	41.0	43.7	
Average	44.1	40.1	51.1	43.6	47.4	38.2	44.1	

* As compared with the yield on pasture stubble not fertilized.

The 6-year (1936-42) average yields following cotton fertilized and not fertilized were essentially the same, and so were the average yields following fertilized and not fertilized stubble pasture. In other words, fertilizing the cotton or pasture apparently had no beneficial residual effect on the yields of the succeeding rice crops. It is pertinent to note, however, that the rice grown in rotations with pasture on the average produced 7.4 bushels per acre more than when it followed cotton, which as in the preceeding experiment was dusted with calcium arsenate.

Ten-year Rotations

In the 10-year rotations, which were started in 1934, the plan is to grow 5 consecutive annual rice crops following 5 years of continuous cropping to (1) cotton, (2) native pasture, (3) corn and soybeans, and (4) improved pasture in which clovers and lespedeza are sown. The soybeans are planted in the corn during the last cultivation, and plowed under as a green manure crop. The native and improved pastures are clipped and the clippings left on the land. The first cycle in these rotations is now completed. Five consecutive rice crops have been grown following 5 years in each of the above treatments, but the 1940 crop was destroyed by floods. The annual and average yields of rice are shown in Table 10. The average yield of seed cotton for the 5-year period (1934-39) preceding the rice crops was 584 pounds, and of corn 9.3 bushels per acre. During this same period, rice grown every year produced an average yield of 30.5 bushels per acre or more than twice as many pounds as corn.

TABLE 10—ANNUAL AND AVERAGE YIELDS OF REXORO RICE GROWN IN A 10-YEAR ROTATION FROM 1939 TO 1943, AT CROWLEY, LOUISIANA

Crop For The 5 Years Preceding Rice	Acre Yields In Bushels				
	1939	1941	1942	1943	4-year Average
Cotton	49.2	14.7	36.1	28.4	32.1
Native pasture	71.2	28.6	46.5	41.9	47.1
Corn and soybeans	63.6	31.1	45.1	42.4	45.6
Improved pasture	74.5	33.1	46.4	40.8	48.7
Average	64.6	26.9	43.5	38.4	43.4

The highest 4-year average yield of rice was 48.7 bushels per acre following improved pasture. The average yield following native pasture was 47.1 bushels; after corn plus soybeans, 45.6 bushels; and after dusted cotton 32.1 bushels per acre. Again the highest average yields were obtained following pasture.

These results indicate that improved pastures may be developed and used for a period of 4 to 5 years, and the land then cropped to rice continuously for 4 years or more without any appreciable reduction in the average yield of rice as compared to cropping in alternate years. The improved pasture when well established should be much more valuable for grazing purposes during the resting period than is native stubble pasture, as commonly used.

Residual Effect of Calcium Arsenate on Yields

Fortuna rice was grown in alternate years for a 7-year period (1935-42) in rotation with (1) cotton dusted with calcium arsenate, (2) cotton not dusted, and (3) stubble pasture. The annual and average yields of the rice are shown in Table 11.

TABLE 11 — ANNUAL AND AVERAGE YIELDS OF FORTUNA RICE GROWN IN ROTATION WITH COTTON DUSTED AND NOT DUSTED, AND WITH STUBBLE PASTURE, FROM 1935 TO 1942, AT CROWLEY, LOUISIANA

Year	Acre Yields In Bushels Of Rice Following:		
	Cotton		Stubble Pasture
	Dusted	Not Dusted	
1935	45.7	68.2	48.4
1936	31.0	31.6	31.6
1937	25.0	47.2	38.2
1938	27.7	39.6	37.4
1939	39.1	59.0	49.5
1941	27.7	35.5	34.1
1942	27.4	34.6	34.9
Average	31.9	45.1	39.2

Each year, the yield of rice was higher following cotton not dusted than following cotton dusted, the average difference being 13.2 bushels per acre. A reduction in yield on dusted cotton land occurred even though only a few straight-head plants were observed, due presumably to the calcium arsenate having been washed off the cotton plants into the soil. The average yield of rice after stubble pasture was 39.2 bushels, or somewhat less than the yield following non-dusted cotton.

Continuous Cropping

Practical experience indicates that rice yields on reasonably fertile soils usually decrease in successive years when grown continuously on the same land. At the Rice Experiment Station, a tenth acre plot has been continuously cropped to rice since 1893, 1942 being the 49th crop. Yields have been recorded each year for the past 30-year period (1913-1942). From 1913 to 1918, inclusive, the Honduras variety, and from 1919 to 1942, inclusive, the Wataribune variety has been grown. The annual and average yields grouped by 5-year periods are shown in Table 12.

TABLE 12—ANNUAL AND 5-YEAR AVERAGE YIELDS OF RICE GROWN CONTINUOUSLY ON THE SAME LAND, FROM 1913 TO 1942, INCLUSIVE, AT CROWLEY, LOUISIANA

Year And Yield Per Acre In Bushels											
Year	Bu.	Year	Bu.	Year	Bu.	Year	Bu.	Year	Bu.	Year	Bu.
1913	51.1	1918	27.2	1923	13.6	1928	25.8	1933	32.9	1938	27.1
1914	49.4	1919	24.7	1924	22.9	1929	21.6	1934	21.3	1939	31.8
1915	27.8	1920	27.2	1925	28.9	1930	26.9	1935	29.6	1940	—
1916	18.2	1921	28.1	1926	27.8	1931	33.6	1936	24.4	1941	33.8
1917	21.3	1922	15.5	1927	35.3	1932	26.9	1937	16.4	1942	35.1
Average	33.6		24.5		25.7		27.0		24.9		32.0

The 5-year average yields for each successive 5-year period are 33.6, 24.5, 25.7, 27, 24.9 and (omitting 1940 when the crop was severely damaged by floods) 32.0 bushels per acre, respectively. The average yields grouped by 10-year periods are as follows: 1913-22, 29.1 bushels; 1923-32, 26.3 bushels; and 1933-42 (omitting 1940), 28 bushels per acre. These averages are not markedly different, the difference between the first and last 5-year periods being only 1.6 bushels per acre, and between the first and last 10-year periods only 1.1 bushels per acre. The average yield for the 29-year period is 27.8 bushels.

The results suggest that with good cultural practices and weed control, average yields of from 25 to 30 bushels per acre may be expected for a period of 30 years or more on continuously cropped Crowley silt loam.

In this connection, it is of interest to note that in a number of Oriental countries, the average yields of rice, on land not fertilized and largely continuously cropped, ranges from 21 to 34 bushels per acre. For example, the 5-year (1930-31 to 1934-35) average yield for Indo-China is 21 bushels, for the Philippine Islands 22 bushels, Burma 25 bushels, British India 28 bushels, the Netherland Indies 30 bushels, and Thailand 32 bushels per acre. These figures indicate that most rice soils, when continuously cropped and kept well weeded, are capable of maintaing rather low average yields for a long period. Rice has been grown for hundreds of years in some of these countries, and yet, the soil is not exhausted, though the average yields are low as compared to countries like Japan and China in which compost, green manure crops, and fertilizers are often used.

It is also of interest to note that on Crowley silt loam, cropped in alternate years, with good cultural practices, the average yield of rice is 50 bushels per acre, as compared with 28 bushels on continuously cropped land. Based on these yields, in a 30-year period, an acre cropped in alternate years would produce a total of 750 bushels, and when continuously cropped 840 bushels, a difference of 90 bushels in favor of continuous cropping. It is of course much more economical, on relatively cheap land which can in alternate years be used for cattle pasture and provide some income above taxes, to prepare the land, seed, irrigate, and harvest 15 good crops in 30 years than it is to grow a relatively low-yielding crop each year. Therefore, in commercial rice production in Louisiana, alternate cropping is practiced because the crop can be produced at a lower cost per acre and per bushel by this method. In much of the Orient, land is expensive, labor is cheap, modern machinery is not usable, and intensive rather than extensive methods of production are used. With these conditions, more rice can be produced by growing it continuously on the same land than in rotation with other crops. Also, rice is the favorite article of food, and when grown in rotation it usually is with other food crops such as wheat, barley, corn, sugarcane, legumes and vegetables.

In all the rotations, for which results are reported, the highest average yields were, in most cases, obtained by growing rice on stubble or on improved pasture land. The former is the common practice in Louisiana for, as a rule, the returns on such intertilled crops as cotton, corn, and soybeans, grown during the resting period have not been entirely satisfactory whereas rice farmers always receive some annual cash income from cattle grazed on stubble land. The native stubble pastures, however, have a rather low carrying capacity, especially during cold and dry periods, and hence, the more general use of improved pastures should be encouraged. Jenkins (6) reported that the seeding of Bermuda and Dallis grasses, white clover, and common lespedeza on pastures and the use of lime and fertilizers improved the growth of pasture plants materially, and the carrying capacity of the pastures. It takes time to establish a good pasture in the rice area, but results indicate that from the standpoint of both rice and cattle production, the change to improved pasture should be profitable.

FERTILIZER EXPERIMENTS

The results of fertilizer experiments conducted at the Rice Experiment Station in earlier years have been reported by Chambliss and Jenkins (2). They are not especially encouraging, for only small or no increases in yield were obtained from the application of acid phosphate, ammonium sulphate, sodium nitrate, or cottonseed meal when applied alone. Potassium sulphate applied alone and with ammonium sulphate, and dried blood alone, gave small increases in average yields. After a lapse of several years during which time additional land was acquired, more extensive experimental work with fertilizer was undertaken. Most of the experiments were conducted on the land acquired in 1930, which, prior to starting these experiments, was fallowed for three or more years to eradicate red rice. Consequently, this area is more productive than the original station land on which other fertilizer experiments were located. Contrary to usual expectation, the response of the rice crop to fertilizers is better on the productive than on the less productive original station land. This confirms earlier conclusions made by Sturgis (9). The results with the same fertilizer, for example, may agree, but the extent of the increase varies with the relative productivity of the land.

The experiments include studies of the effect of compost, straw with and without fertilizer, complete fertilizers with phosphorous from different sources and applied at different rates, residual effect of phosphorous, ammonium sulphate and ammophos applied at different dates, complete and incomplete fertilizer formulas, and rates of application of complete and incomplete fertilizers on the yields of rice. The grade or formula of a mixed fertilizer indicates the amount of the plant food elements nitrogen, phosphoric acid, and potash present in the fertilizer. Thus, an 8-10-6 fertilizer contains 8 percent of nitrogen, 10 percent of phosphoric acid, and 6 percent of potash, or a total of 24 percent of these plant food elements. A complete fertilizer is one containing the 3 principal elements of plant food, nitrogen, phosphorous and potassium.

Compost

In one experiment, compost (consisting of rice straw to which ammonium sulphate was added to promote decay) was applied to single

TABLE 13 — THE EFFECT OF COMPOST ON THE YIELDS OF FORTUNA RICE AT CROWLEY, LOUISIANA., 1926-43[1]

Acre Yields In Bushels							
Year	Compost	No Treatment	Increase	Year	Compost	Treatment	Increase
1926	65.1	71.8		1933	41.4	37.1	
1927	30.7[2]	20.0[2]		1934	27.2	29.8	
1928	51.8	49.8		1935	32.0	29.2	
1929	49.1	46.2		1936	22.5	22.2	
1930	40.7	38.9		1937	33.7	32.0	
1931	52.0	48.7		1938	49.0	41.8	
1932	48.4	41.6		1939	40.3	34.3	
				1941	34.3	40.0	
				1942	40.3	25.4	
				1943	33.1	24.5	
7-year Average 1926-32	48.2	45.3	2.9	10-year Average 1933-43	35.4	31.6	3.8
17-year Average 1926-43					41.8	38.5	3.3

[1] Original Station Land.
[2] Poor stands.

plots at the rate of 2 tons per acre from 1926 to 1932, and at the rate of 4 tons per acre in duplicate plots from 1933 to 1942, inclusive, in comparison with unfertilized plots. The Fortuna variety was grown. The annual and average yields are given in Table 13.

The average yield of the plots treated at the rate of 2 tons per acre, for the 7-year period (1926-32) was 48.2 bushels, and for the check plots 45.3 bushels, or an increase of only 2.9 bushels per acre. For the 10-year period (1933-43), the average yield of the plots treated at the rate of 4 tons per acre was 35.4 bushels, and that of the untreated plots 31.6 bushels, an increase of 3.8 bushels per acre. The average yield for the 17-year period (1926-43) was 41.8 bushels for the treated, and 38.5 bushels for the untreated check, or an increase of 3.3 bushels per acre.

Straw With And Without Fertilizer

Six years' data (1937-43) are available for an experiment conducted to determine the effect of 3 tons of straw turned under in the fall immediately after harvesting the rice crop, with rice grown continuously and in alternate years, the land when not in rice being in stubble pasture; also, with and without 400 pounds of a complete (8-10-6) fertilizer, half applied with the straw and half with the seed. The straw alone was not included the first year. The Rexoro variety was grown, and each treatment was replicated 4 times. The annual and average yields are given in Table 14.

TABLE 14—THE EFFECT OF STRAW ALONE AND STRAW PLUS A COMPLETE FERTILIZER ON THE YIELDS OF REXORO RICE AT CROWLEY, LOUISIANA, 1937-43

Treatment	Acre Yields In Bushels							
	1937	1938	1939	1941	1942	1943	6-year Average 1937-43	Average Increase
	Alternate Cropping							
No Straw or Fertilization (ck.)	44.2	71.0	47.2	48.4	65.3	35.5	50.1	——
3 Tons of Straw	——	72.3	55.1	57.5	55.9	49.2	58.0 [1]	4.5 [1]
3 Tons of Straw and Fertilizer	53.9	78.2	71.8	61.8	73.4	61.0	66.7	16.6
	Continuous Cropping							
No Straw or Fertilizer (ck.)	49.1	62.9	37.9	45.2	40.7	35.1	45.2	——
3 Tons of Straw	——	63.7	48.2	47.3	45.4	42.5	49.4 [1]	5.0 [1]
3 Tons of Straw and Fertilizer	67.1	69.4	69.4	53.8	56.2	50.0	61.0	15.8

[1] Five-year average (1938-1943) yields and increases

The 5-year average increase in yields from the application of 3 tons of straw alone was only 4.5 bushels for the alternately cropped, and 5.0 bushels per acre for the continuously cropped plots. These differences are not statistically significant. The 6-year (1937-43) average increase in yields from the application of straw plus fertilizer was 16.6 bushels for the alternately cropped and 15.8 bushels per acre for the continuously cropped plots. These differences are statistically significant, and indicate that to get the maximum benefit from the application of straw, it is necessary to use fertilizer. The average yields of the unfertilized plots indicate that the land was relatively fertile as compared to most other areas on the Station. The results of this experiment and of the preceding experiment, in which compost was used, indicate that the plowing under of rice straw and the addition of compost improves the productivity of rice soils low in organic matter. The additional increases secured by the use of fertilizers with straw also suggest the need of applying both.

Complete Fertilizer With Three Sources Of Phosphorous

In 1937, a fertilizer experiment was begun to determine the comparative effect on rice fields of complete fertilizers with three different sources of phosphorous. This experiment was conducted with rice grown in alternate years on land that in the 4 years preceding 1937 had been devoted to improved pasture. The phosphorous, namely T. V. A. treble phosphate, T. V. A. fused phosphate, and bone meal, was applied in an 8-10-6 formula at seeding time at the rate of 400 pounds per acre. The Rexoro variety was grown from 1937-41, and Blue Rose 41 in 1942 and 1943. Each treatment was replicated 4 times. The annual and average yields are given in Table 15.

TABLE 15—THE EFFECT OF PHOSPHORUS FROM THREE DIFFERENT SOURCES ON THE YIELDS OF REXORO RICE AT CROWLEY, LOUISIANA, 1937-43

Fertilizers Used	Acre Yields In Bushels							
	1937	1938	1939	1941	1942	1943	Average	Average Increase
No. Fertilizer (ck.)	52.6	58.5	67.6	60.9	47.2	47.4	55.7	——
T. V. A. Treble Superphosphate	62.9	65.7	77.7	74.0	72.8	67.4	70.1	14.4[1]
Bone Meal	57.4	66.6	76.6	76.2	66.4	66.2	68.2	12.5[1]
T. V. A. Fused Phosphate	60.6	67.4	73.8	78.0	67.8	67.2	69.1	13.4[1]

[1] Significant at 5 percent level on basis of paired plots compared with the checks.

The three sources of phosphorous all gave marked increases in average yields. The average increase for the 6-year period (1937-43) for the T. V. A. Treble phosphate was 14.4, for T. V. A. fused phosphate 13.4, and for bone meal 12.5 bushels per acre, respectively. These increases are statistically significant, and indicate that the three sources of phosphorous were about equally effective in increasing yields. The yield of the check plots was 55.7 bushels per acre, indicating that this land was in a higher state of fertility than most other areas on the Station.

Complete Fertilizers With Six Sources Of Phosphorous Applied At Different Rates

An experiment combining sources of phosphorous and rates of application was conducted in 1939, 1941, and 1942. The phosphates were applied in an 8-10-6 formula at seeding time at the rate of 100, 200, and 300 pounds per acre, on land cropped in alternate years. The Rexoro variety was grown and each treatment was replicated 4 times. The annual and average yields are shown in Table 16.

TABLE 16 — THE EFFECT OF PHOSPHORUS FROM SIX SOURCES, APPLIED AT DIFFERENT RATES, ON THE YIELDS OF REXORO RICE AT CROWLEY, LOUISIANA, 1939-42.[1]

Fertilizers Used	Acre Yields In Bushels												Average
	1939			1941			1942			3-yr. Average (1939-42)			
	Rate of application (lbs.)												
	100	200	300	100	200	300	100	200	300	100	200	300	
No. Fertilizer (ck)	36.6	42.4	34.3	19.5	22.2	20.8	36.6	41.3	38.3	30.9	35.3	31.1	32.4
Superphosphate	41.0	51.4	48.7	24.9	27.6	28.6	37.0	36.0	41.3	34.3	38.3	39.5	37.6
Basic Slag	38.0	50.4	41.7	25.9	25.9	18.2	37.3	39.3	41.7	33.7	38.5	33.8	35.4
Bone Meal	42.5	52.4	45.4	25.6	24.2	20.8	38.0	38.0	36.6	35.3	38.2	34.3	35.9
T. V. A. Fused Phosphate	44.4	50.8	50.4	28.9	27.6	21.5	35.6	37.3	36.6	36.3	38.5	36.2	37.0
T. V A Ca-meta Phosphate	46.0	50.8	50.5	22.9	27.2	24.5	37.0	39.3	44.4	35.3	39.1	39.8	38.1
Colloidal Phosphate	45.4	53.3	41.2	27.6	29.6	30.9	39.0	38.3	45.4	37.3	44.0	39.2	40.0
Average	35.9	50.2	44.6	25.0	26.3	23.6	37.2	38.5	40.6	—	—	—	—

[1] Original Station Land

Three years is too short a period to give conclusive results, but certain trends are indicated. The average increases in yields for all sources of phosphorous were, for the 100-pound rate 4.5 bushels, for the 200-pound rate 4.1 bushels, and for the 300-pound rate 6.0 bushels per acre. For the 3 rates combined, the highest average yields were for colloidal phosphate 40.0 bushels, T. V. A. Ca-meta phosphate 38.1 bushels, and for superphosphate 37.6 bushels per acre, which indicate that each of these sources of phosphorous is satisfactory for rice, since the unfertilized plots averaged only 32.4 bushels per acre.

At the 100-pound rate of application, the highest average yields were for colloidal phosphate 37.3 bushels, or a gain of 6.4 bushels as compared with the unfertilized check, for T. V. A. fused phosphate 36.3, and for T. V. A. Ca-meta phosphate 35.3 bushels per acre. At the 200-pound rate, the highest average yields were for colloidal phosphate 44.0 bushels or a gain of 8.7 bushels, for T. V. A. Ca-meta phosphate 39.1, and for T. V. A. fused phosphate and basic slag 38.5 bushels per acre. At the 300-pound rate, the highest average yields were for T. V. A. fused phosphate 39.8 bushels or a gain of 8.1 bushels, for superphosphate 39.5 bushels, and colloidal phosphate 39.2 bushels per acre. Colloidal phosphate was the best at two rates and as good as the best at the third rate. The increases in yield even for the higher rates of application are somewhat less than were secured in the preceding experiment because the land was in a lower state of productivity. It has been the general experience at the Crowley Station that the best response to fertilizer is secured on land above average in productivity.

Residual Effect of Phosphorous

Beginning in 1933, duplicate plots were fertilized with a 2-25-3 formula at the rate of 1600 pounds per acre each year until 1937, after which no fertilizer was applied. Rice was grown each year up to and including 1942, the variety Fortuna being used. The annual and average yields, together with those of the check plots, are given in Table 17.

TABLE 17 — THE RESIDUAL EFFECT OF PHOSPHATE FERTILIZER ON YIELDS OF FORTUNA RICE (1933-42), AT CROWLEY, LOUISIANA.[1]

Year	Yield Per Acre In Bushels	
	Fertilized	Not Fertilized
1933	60.0	47.3
1935	30.5	23.9
1936	24.2	33.7
1937	37.0	42.4
1938	40.3	47.7
1939	25.6	39.0
1941	26.9	28.9
1942	35.6	22.9
Average	35.0	35.7

[1] Original Station Land.

The average yield of the fertilized plots for the entire period was 35 bushels and of the check plots, 35.7 bushels per acre. The average yield for the 4 years (1933-37) for the fertilized plots was 37.9, and for the check plots 36.8 bushels per acre, and 32.1 and 34.6, respectively, for the following 4 years. These results indicate that an unusually heavy pplication of a phosphate fertilizer on continuously cropped land had no appreciable effect on the average yields during the years that it was applied, nor during the succeeding 4-year period. In this experiment, the amounts of nitrogen and potassium applied in the earlier years were probably too small to have an appreciable immediate or residual effect on yields.

Ammonium Sulphate and Ammophos

An experiment to determine the effect of ammonium sulphate and ammophos (8-10-0) on the yields of rice grown on continuously cropped land was started in 1937. Each fertilizer was applied at the rate of 400 pounds per acre with the seed, on the water 3 weeks after irrigation, and on the water 8 weeks after irrigation. The Rexoro variety was grown, and the irrigation water was applied 20 days after seedling emergence. The plots were replicated 4 times. The annual and average yields are shown in Table 18.

TABLE 18 — THE EFFECT OF AMMONIUM SULPHATE AND AMMOPHOS ON THE YIELDS OF REXORO RICE AT CROWLEY, LOUISIANA, (1937-42).

Fertilizer And Time Of Application	Acre Yields In Bushels						
	1937	1938	1939	1941	1942	Average	Average Increase or Decrease
No fertilizer (check)	37.1	42.4	39.1	37.5	30.4	37.3	—
Ammonium Sulphate With Seed	35.0	38.9	30.0	39.5	35.1	35.7	-1.6
Ammonium Sulphate 3 Weeks After Irrigation	34.6	41.8	37.1	39.1	31.7	36.9	-0.4
Ammonium Sulphate 8 Weeks After Irrigation	43.6	46.2	34.9	40.7	32.5	39.6	2.3
Ammophos With Seed	39.4	45.6	38.7	28.8	38.7	38.3	1.0
Ammophos 3 Weeks After Irrigation	43.3	42.8	37.9	30.8	33.9	37.7	0.4
Ammophos 8 Weeks After Irrigation	36.4	51.0	48.2	35.7	41.5	42.6	5.3

Applications of ammonium sulphate at seeding and 3 weeks after irrigation gave slightly lower, and ammophos applied at the same time gave slightly higher average yields than the check plots. In neither case were the differences significant. Each fertilizer when applied 8 weeks after irrigation, however, gave small increases in average yields, though the increases were probably too small to cover the cost of the fertilizers and their application under normal conditions. These results suggest that the use of ammonium sulphate or ammophos alone on land cropped each year is not likely to be profitable, but this is not necessarily so on land cropped in alternate years, as shown in the following experiment.

Complete and Incomplete Fertilizers

A fertilizer experiment in which various formulas including complete and incomplete fertilizers were compared was started in 1939. Each fertilizer was applied with the seed on land cropped in alternate years at the rate of 200 pounds per acre. The Rexoro variety was grown and each treatment was replicated 4 times. The annual and 4 year (1939-43) average yields are shown in Table 19.

TABLE 19 — THE EFFECT OF COMPLETE AND INCOMPLETE FERTILIZERS ON THE YIELDS OF REXORO RICE AT CROWLEY, LOUISIANA, 1939-43.[1]

Fertilizers Used	Acre Yields In Bushels					
	1939	1941	1942	1943	4-year Average 1939-43	Average Increase
0-10-6	37.6	22.5	33.6	22.8	29.2	0.4
4-10-6	45.7	30.6	38.6	27.6	35.6	6.8
8-10-6	46.4	33.3	39.3	29.9	37.2	8.4
12-10-6	41.0	30.9	42.7	30.6	36.3	7.5
8-0-0	42.7	26.2	38.3	37.3	36.1	7.3
None (ck)	32.6	19.5	41.3	24.9	29.6	—
8-0-6	37.6	25.2	35.6	34.6	33.3	4.5
8-5-6	42.4	25.9	44.7	26.6	34.9	6.1
8-15-6	42.4	23.2	39.0	25.2	32.5	3.7
0-10-0	36.6	25.2	36.6	23.2	30.4	1.6
None (ck)	33.9	22.9	34.0	23.2	28.5	—
8-10-0	37.0	31.9	43.7	21.8	33.6	4.8
8-10-3	40.7	32.6	40.0	21.2	33.6	4.8
8-10-9	44.7	30.2	40.7	20.5	24.5	5.7
0-0-9	34.6	25.2	35.6	16.1	27.9	-0.9
None (ck)	34.0	21.8	37.0	19.8	28.2	—

[1] Original Station Land.

The highest 4-year average yields were 37.2 bushels with the 8-10-6, 36.3 bushels with the 12-10-6, and 36.1 bushels per acre from the 8-0-0 formula. In the order listed, the increases over the check plots were 8.4 bushels, 7.5 bushels, and 7.3 bushels per acre, respectively. The increases for the 0-10-6, 0-10-0, and 0-0-9 formulas were very small. These results, as for others discussed, indicate (1) that a complete fertilizer is more effective in increasing yields than either of the three elements applied alone, and (2) that of the complete fertilizers tested, the 8-10-6 is best, closely followed by the 12-10-6, 8-5-6, and 8-10-9 formulas.

Rates of Application of Complete and Incomplete Fertilizers

In an experiment conducted 4 years, complete and incomplete fertilizers were applied on the water 8 weeks after the land was submerged, at the rate of 100, 200, and 300 pounds per acre on land cropped in alternate years. The Rexoro variety was grown, and each treatment was replicated 4 times. The annual and average yields are given in Table 20.

TABLE 20 — THE EFFECT OF COMPLETE AND INCOMPLETE FERTILIZERS APPLIED AT DIFFERENT RATES ON THE YIELDS OF REXORO AT CROWLEY, LOUISIANA, 1939-43.

Rates of application and fertilizers used.	Acre Yields In Bushels					
	1939	1941	1942	1943	4-year Average 1939-43	Average Increase
100 pounds per acre:						
8-0-0	56.8	35.2	44.1	49.3	46.4	0.3
0-10-0	56.1	33.0	49.1	46.5	46.2	0.1
8-10-0	54.9	39.3	49.1	47.1	47.6	1.5
8-10-6	61.7	42.4	56.8	50.2	52.8	6.7
Check	56.4	35.2	47.0	45.8	46.1	—
200 pounds per acre:						
8-0-0	57.1	35.2	44.3	52.4	47.3	0.0
0-10-0	57.7	34.0	49.6	53.6	48.7	1.4
8-10-0	68.6	36.2	57.4	57.7	55.0	7.7
8-10-6	65.5	45.5	62.0	57.1	57.5	10.2
Check	59.9	35.2	44.0	50.2	47.3	—
300 pounds per acre:						
8-0-0	58.0	31.5	50.8	53.6	48.5	0.6
0-10-0	64.9	32.7	57.7	54.9	52.5	4.6
8-10-0	65.8	29.0	63.6	52.7	52.8	4.9
8-10-6	69.5	39.0	69.5	53.6	57.9	10.0
Check	56.8	36.5	47.4	51.1	47.9	—

The largest increases were secured from the 200- and 300-pound rates of application and with complete fertilizers and those containing both nitrogen and phosphorous. The complete fertilizer (8-10-6) applied at the 200-pound rate was the most economical. Nitrogen alone

(8-0-0), and phosphorous alone (0-10-0), failed to materially increase yields, but nitrogen and phosphorous together (8-10-0) gave an increase of 7.7 bushels per acre at the 200-pound rate.

This experiment and the preceding one are closely related since they deal primarily with a comparison of different fertilizer formulas. The results agree in suggesting that material increases in yield should not be expected except with a complete fertilizer or at least one that contains both nitrogen and phosphorous. Phosphorous alone, which in general seems to be needed even more than nitrogen, and likewise phosphorous combined with nitrogen gave at the higher rates relatively small increases in yield. The land, however, was not in a high state of fertility in the first-mentioned experiment, as shown by the relatively low yields of the check plots. The results with rates of application suggest that at least 200 pounds per acre should be applied.

In a somewhat similar experiment, Rexoro was grown on land cropped in alternate years to which 400 pounds of a complete fertilizer (8-10-6) was applied (1) with the seed, and (2) 200 pounds with the seed plus 200 pounds on the water 8 weeks after submergence, were compared. The data are not tabulated, but the 4-year (1939-43) average yield of the unfertilized check plots was 54.3 bushels, for the 400-pound rate applied with the seed 56.5, and for the spilt application 63.4 bushels per acre. The average increase for the application with the seed was 2.2 bushels, and when half of the fertilizer was applied with the seed and the other half on the water 8 weeks after submergence 9.1 bushels per acre. The spilt application was therefore much more effective.

The results of recent fertilizer experiments in other rice producing States are briefly reviewed below.

Nelson (8), in Arkansas, reported significant increases in the average yields of rice from the application of 500 pounds per acre of (1) a complete (4-8-4) fertilizer 6 or 8 weeks after seeding; (2) ammophos (4-8-0), and ammophos plus sulphate of potash (4-5-4) 6 weeks after seeding; and (3) ammonium sulphate (4-0-0) 4 weeks before and 10 weeks after seeding. The residual effect of fertilizers used on preceding crops did not result in a marked increase in the yield of the succeeding rice crop.

Wyche (10), at the Rice Experiment Station, Beaumont, Tex., reported increased yields from the application of sulphate of ammonia alone. Phosphoric acid alone did not increase yields, but a combination of sulphate of ammonia and phosphoric acid was superior to nitrogen alone during the latter period of the test. He found that the response of soils to the application of fertilizers varied in different localities. In Liberty County, nitrogen alone gave practically no increase in yields, whereas, phosphoric acid increased yields and a combination of nitrogen and phosphoric acid increased yields materially. In Orange County, phosphoric acid alone gave a marked increase in yields, but nitrogen alone did not increase yields. At Beaumont, sulphate of ammonia alone and a combination of sulphate or ammonia and phosphoric acid, when drilled in with the seed, gave a larger yield of rice than when broadcast on the surface of the soil. As sources of phosphorus, bone meal and superphosphate were of essentially the same value. The minor plant food elements, iron, manganese, copper, zinc, and boron, did not appear to be deficient on the soils used. On the principal rice soils of the Texas area, a fertilizer containing 20 pounds each of nitrogen and phosphoric acid, in the form of sulphate of ammonia and superphosphate, applied with the seed when drilled, is recommended.

Davis and Jones (4), in California, reported marked increases in the average yields of rice from applications at seeding time of 100, 150, and 200 pounds of ammonium sulphate per acre. With the Caloro variety, the 150-pound rate gave the largest increase in yield and net return per acre; whereas, with the Colusa variety, the 200-pound rate was most profitable. The application of ammonium sulphate at seeding time was more effective in increasing yields than when applied during the tillering or heading stages of growth. During a 5-year (1932-36) period, rice was grown on land fertilized with ammonium sulphate, ammophos, leunasalpeter, urea, ammosphosko, leunaphos, calurea, and cyanamide, at rates that added 21, 31.5, and 42 pounds of nitrogen per acre, respectively. At each rate of application, ammonium sulphate was most profitable. The application of superphosphate and potassium sulphate alone and in combination failed to increase yields materially.

Rice is of course grown on various soil types and under different environmental conditions, and for this reason, it is not unusual to find marked variability in the response of the crop to fertilizers. On some soils, nitrogeneous fertilizers alone give marked increases in yields, on others the crop responds better to phosphorus than to nitrogen, and often fertilizers containing both nitrogen and phosphorus are more effective in increasing yields than either element applied alone. In general, most rice soils appear to contain sufficient available potash to produce relatively high yields.

PERMANENT-PASTURE EXPERIMENT

The general practice in rice farming is, as has been stated, to grow a crop, then use the land for cattle pasture the following year. The farm is usually divided into two main parts, one sown to rice and the other grazed in alternate years. The cattle are used mainly to destroy weeds on land intended for rice the following year. The practice has resulted in the use of low-grade cattle that have received little attention, and often little or no profit has been obtained directly from the cattle. During the summer and fall months, there usually is sufficient growth on the land to keep cattle in fair condition, but this is not true in dry years. The principal growth for summer grazing is volunteer red rice, an objectionable variety, and the most troublesome weed in rice fields.

Rice farmers are coming to realize it is possible to make cattle raising as an adjunct to rice growing a more profitable enterprise, and there is need for information as to how this can best be accomplished.

One of the problems is lack of feed during the winter and spring, since there is very little growth of any kind on land which grew rice the previous year. Land grazed in the summer is usually plowed in the fall, in preparation for the next rice crop, and this destroys most of the vegetation. While rice straw is abundant and has some food value, it alone will not satisfactorily sustain cattle. This is emphasized by the poor condition of the cattle and the large number that die, especially in sever winters.

An experiment accordingly was undertaken in 1932 to determine what permanent pasture crops can be grown on rice lands in southwestern Louisiana, and to secure information relative to the best treatment of such pastures. These consisted of comparisons of various grasses and clovers and of fertilizer treatments.

The experiment was conducted in 14 large single plots, ranging in size from about 1/7 to 1/4 of an acre, three of which were fertilized and limed, five were fertilized only, three received lime only, and three received neither fertilizer nor lime. The fertilizers were applied at the time the land was prepared for seeding in January, 1932, at the rate of 600 pounds of 16 percent superphosphate and 200 pounds of muriate of potash per acre. The following spring, ground limestone was applied in one application at the rate of 2,000 pounds per acre to plots receiving lime. No fertilizer or lime was again applied until April 15, 1938, when the fertilized plots received 1,000 pounds of a 5-15-5 formula, and on February 10, 1939, the limed plots received 1,000 pounds of lime per acre.

Four plots were seeded to a mixture of Bermuda grass, white clover, and common lespedeza; four to a mixture of Bermuda grass, Dallis grass, lespedeza, Persian clover, and white clover; and the remaining six plots were **not** seeded. All plots were prepared in the same manner, except those **not** seeded were left for a natural growth to develop. The land had in the past several years been in various crops including rice, soybeans, and grass. Most of the growth during the first two years consisted of native grasses.

On December 15, 1937, all plots except one (No. 8) that had not been seeded were disked and treated as in the beginning, except that no Persian clover was seeded.

The plots were mowed several times during the first growing season (1932), but no attempt was made to estimate yields as the plants had not become well established. In subsequent years, the plots were not grazed but were mowed once each month during the growing season. The hay was removed from the mowed pastures. Mowing in some years began as early as the latter part of March, and continued until the first week in October. The yields each year were estimated by clipping five 5-foot square areas from each plot. Aliquot weights of green matter from each plot were cured, and from this the yield per acre in cured hay was estimated. The yields for 1940 were not complete on account of a flood.

Very good stands of lespedeza and Bermuda grass were secured. The stand of Dallis grass was fair. In the succeeding years (1932-37), however, there was a gradual change in the vegetation. Very little white clover was noted after 1932, and Persian clover had practically disappeared by 1934. Lespedeza began to decrease after 1934, but remained scattered throughout all plots until the fall of 1937. By 1937, very little Dallis or Bermuda grass was noted. Up to this time, these grasses had remained green each year for a longer period than other kinds of vegetation. Carpet began to increase in 1936, and by the fall of 1937 it was the predominating grass in all plots.

By the end of the third year, the plots not seeded contained much the same growth as those that had been seeded. This was due to the fact that carpet grass, Bermuda grass, and common lespedeza produce viable seed that became scattered over the adjoining plots. The seed is probably distributed by wind and water from heavy rains. In the early spring of some years, hop clover was abundant in all plots and greatly increased the yield of hay.

The stimulating effect of lime on clovers and grasses in the early part of the season was noticeable in most years. The effect was most striking on white clover, a few plants of which were found in limed plots as late as 1937. The poorest growth of lespedeza, however, was on the limed plots.

In the period from 1938 to 1943, inclusive, that is after the original treatments had been repeated in 1937, the behavior of the different kinds of plants and the effect of lime were practically the same as indicated for the period from 1932 to 1937, inclusive, except that carpet grass became more general throughout the plots by the end of the second season.

The plot left undisturbed during the eleven years had a stand throughout most of that time and up to the fall of 1943, of a rather uniform mixture of carpet grass and common lespedeza.

The annual and 10-year average yields of cured hay are given in Table 21.

TABLE 21 — YIELDS OF HAY, IN TONS PER ACRE, FROM PERMANENT PASTURES ESTABLISHED AND TREATED IN VARIOUS WAYS, CROWLEY, LOUISIANA, (1933-43)

Year	Bermuda Grass, White Clover, and common lespedeza				Bermuda Grass, Dallis Grass, common lespedeza, Persian Clover, and White Clover				Native Grass				Native Grass	
	Limed		Not Limed		Limed		Not Limed		Limed		Not Limed		Sod Broken as Necessary Not Limed Fertilized	Sod Not Broken Not Limed Fertilized
	F[1]	NF[2]	F	NF	F	NF	F	NF	F	NF	F	NF		
1933	5.74	4.14	5.35	4.27	5.18	4.16	4.30	3.71	3.34	2.64	3.13	3.20	3.97	3.65
1934	5.26	3.78	3.89	3.46	5.08	2.07	3.93	2.79	4.08	3.45	3.67	2.82	2.90	2.94
1935	4.28	3.53	3.25	2.70	3.59	3.20	2.81	2.90	3.25	3.19	3.64	3.40	2.39	2.63
1936	1.92	2.00	1.82	1.77	1.58	1.60	1.56	1.44	1.62	2.00	1.81	1.67	1.28	1.89
1937	2.52	2.22	2.59	1.76	2.42	1.50	2.09	1.28	2.07	1.50	2.35	1.48	1.38	1.27
1938	2.41	2.10	1.77	1.82	1.94	1.71	1.51	1.53	1.90	1.62	2.09	1.34	1.38	1.19
1939	1.79	1.90	1.87	1.73	2.07	1.52	1.93	1.36	1.61	1.75	1.60	1.57	1.29	1.27
1941	3.03	3.22	2.49	1.97	2.78	3.14	2.89	2.73	3.11	3.17	2.87	1.86	1.68	1.60
1942	3.11	2.88	2.94	2.41	2.70	2.86	2.56	2.10	2.73	2.39	2.78	2.06	1.83	1.77
1943	1.94	1.96	1.96	2.03	1.89	2.04	2.04	1.55	1.80	1.52	1.84	1.74	1.62	1.77
Av.	3.05	2.62	2.64	2.23	2.77	2.22	2.44	2.02	2.41	2.20	2.43	2.03	1.84	1.86

[1] F—Fertilized
[2] NF—Not Fertilized.

The highest 10-year average yield (3.05 tons per acre) was from the plot seeded to Bermuda grass, white clover, and common lespedeza, limed and fertilized. The lowest average yield (1.84 tons per acre) was from native grasses with the sod broken in the fifth year and fertilized but not limed. Lime increased the average yields of all plots 0.26, fertilizer 0.41, and both lime and fertilizer 0.65 tons of cured hay per acre. There was practically no difference in the average yields of the two plots of native grasses, one fertilized on sod broken and reprepared in the fifth year and the other fertilized but the sod not broken.

In this experiment, the monthly cutting of the clovers prevented the setting of appreciable quantities of seed which would normally occur if the plots were grazed. Since Persian clover is a winter annual and white clover principally behaves as a winter annual in the southern States, adequate quantities of seed of each species are needed each fall to establish volunteer stands. A thick growth of grass in the fall also prevents the establishment of stands of clovers. Many rice growers throughout the Gulf Coast region are successfuly growing winter annual clovers under grazing conditions with adequate mineral fertilization.

DISCUSSION

In the preceding experiments, it has been shown that the yield of rice is materially affected by the variety grown, by the method of irrigation used, by the rotation system followed, and by the kind amount and time of application of fertilizers.

Of the varieties tested, the early-maturing Zenith and Early Prolific; the midseason Acadia, Blue Rose, Nira, and Fortuna; and Rexoro, which matures late, are best adapted for growing in Louisiana. These include short-, medium- and long-grain varieties that differ materially in market value. These varieties also react differently when sown from early to late in the spring, and this makes it possible for growers to choose varieties for seeding on successive dates so that the harvest can be extended over a long period and thus use to best advantage the harvesting equipment and labor available.

Grasses and aquatic weeds must be controlled in order to produce satisfactory yields of rice. Fortunately, grasses usually can be controlled by thorough seedbed preparation and by timely irrigation after the rice seedlings come up. On land submerged in from 10 to 20 days after the seedlings emerge, the growth of grasses is checked, and hence, they cause little or no reduction in yields. On land free of grass, however, submergence can be safely delayed until 30 to 40 days after the seedlings emerge. Grasses also can be controlled by seeding in the water, but the stands and yields obtained by this method were less satisfactory than for properly irrigated drilled rice.

Aquatic weeds are not so troublesome on well prepared seedbeds having good stands of rice. However, in thin stands, these weeds often appear soon after the land is submerged and in low areas with deep water they reduce yields.

Soils of the warm humid sections of the United States often are deficient in organic matter, and this is especially true in the rice area. Therefore, rotations that increase or at least maintain the humus content of the soil should be used. In the present studies, the highest average yields of rice were obtained when the crop was grown in rotations with stubble and improved pastures. Yields were slightly lower following corn and soybeans, and these crops were of less value than pasture. Cotton is not a satisfactory crop for growing in rotation with rice, for it must be dusted with calcium arsenate to control boll weevil and the residual effect of the calcium arsenate materially reduces rice yields. Growing rice in alternate years, or once in three years, on stubble pasture, and following improved pastures gave the best results. To establish improved pastures requires a relatively long time and the longer period in pasture was beneficial to the soil and the succeeding rice crops.

In the fertilizer experiments, the average yields of rice were increased materially by the application of a complete fertilizer at seeding time and 8 weeks after the land was submerged. The largest increases in yields, from the application of fertilizers, were obtained on relatively fertile land, such as improved pasture and land on which straw had been turned under. On less fertile land, the increases were smaller, which indicates that it is necessary to maintain the organic matter in the soil in order to obtain maximum benefits from the use of fertilizers. The source of phosphorous, in a complete fertilizer, was of less importance than the formula used. The largest and most consistent increases in yield were obtained with the 8-10-6 formula.

This fertilizer, applied at seeding time at the rate of 400 pounds per acre, gave the largest increases in yield, but applications at seeding time and 8 weeks after irrigation at the rate of 100, 200, and 300 pounds per acre, also materially increased yields. On weedy land, complete fertilizers applied at seeding time often stimulate the growth of grasses that compete with and may crowd out the rice seedlings. Furthermore, the nitrogen content of fertilizers applied at seeding time, unless absorbed by the soil, may be lost before the seedlings are large enough to utilize it. Thus, fertilizers may, under such conditions, actually reduce yields. On grassy land, therefore, best results often are obtained by applying fertilizers from 4 to 8 weeks after the land has been submerged.

The results presented in the preceding pages indicate that by using well adapted varieties, good cultural irrigation and rotation practices, and suitable fertilizers, the average yield of rice in Louisiana can be increased materially.

SUMMARY

In Louisiana, rice is the second most important cash crop, ranking next to cotton. The principal area of production is in the southwestern part of the State, in Acadia, Vermilion, Jefferson Davis, and Calcasieu parishes. Relatively level clay soils, an ample supply of fresh irrigation water, and a subtropical climate each contribute to the success of rice culture in this area.

Yields of varietal experiments show that Zenith and Early Prolific in the early group, Blue Rose, Fortuna, Nira, and Acadia in the midseason group, and Rexoro in the late group, are well adapted for growing in Louisiana.

In date-of-seeding experiments, the highest average yields of Fortuna, Rexoro, Blue Rose, and Caloro were obtained from seeding about April 1, and for Early Prolific and Nira, from seeding May 1 and May 15, respectively. The number of days required from seeding to maturity, for each variety, decreased as the date of seeding was delayed. Thus, for a difference of 76 days in the time of seeding (March 17 and June 1), there was a spread in dates of maturity of about 50 days for Rexoro, Nira, Fortuna, and Early Prolific, but only about 20 days for Blue Rose and Caloro. This difference in the response of rice varieties when sown on different dates should be borne in mind by growers who plan on seeding so as to distribute the harvest over a relatively long period, and by those who are forced to seed late in the spring.

The highest average yields of the Caloro, Blue Rose, Rexoro, and Fortuna varieties, when sown broadcast in the water, were from seeding on April 1.

In a date-of-submergence experiment, the highest average yields for each variety were obtained on land submerged 20 days after the seedlings had emerged. In a discontinuous and continuous submergence experiment, early (i. e. 10 days after seedling emergence) continuous submergence of the land gave higher average yields than intermittent drying of the land followed by continuous submergence.

Holding water on rice stubble or uncropped land during the fall, winter, and summer, or after late fall plowing until March 1, had no beneficial nor detrimental effect on the average yields of rice.

In 2-year rotations, the highest average yield of rice was 49.7 bushels per acre, following Italian ryegrass, and following clovers on stubble pasture. A slightly lower average yield (48.1 bushels per acre) was obtained following cultivated fallow and following soybeans plus bur clover sown in the fall. The lowest average yield (36.3 bushels) was following cotton dusted with calcium arsenate. The yields of cotton and of soybeans in these experiments were too low to be profitable. In another experiment, the average yield following cotton

dusted with calcium arsenate was 31.9 bushels, and after cotton not dusted 45.1 bushels, a decrease of 13.2 bushels, due apparently to the residual effect of calcium arsenate.

In a 3-year rotation of cotton, soybeans, and rice, the average yields of cotton and soybeans were too low to be profitable, and the average yield of rice was 45.9 bushels per acre, or somewhat less than that from the better 2-year rotation.

In 4-year rotations consisting of two successive rice crops following 2 years in cotton fertilized and not fertilized, and in stubble pasture fertilized and not fertilized, the yields of rice were not increased by fertilizing, but the rice after stubble pasture yielded 7.4 bushels more than that following cotton. In other words, fertilizer applied to cotton or on stubble pasture land did not benefit the succeeding rice crop. The results are in accord with those of other rotation experiments, however, in indicating a material gain from rotating rice with pasture rather than with cotton.

In 10-year rotations of 5 successive rice crops following 5 years each in (1) cotton, (2) native pasture, (3) corn plus soybeans, and (4) improved pasture, the 4-year average yield of rice following improved pasture was 48.7 bushels; after native pasture, 47.1 bushels; after corn plus soybeans, 45.6 bushels; and following dusted cotton, 32.1 bushels per acre.

On land cropped continuously to rice for 49 years, the 5-year average yields for the last 30-year period ranged from 24.5 to 32 bushels per acre. The fluctuations in the 5-year average yields appear to be due to variations in climatic conditions rather than to depletion of the soil fertility.

In fertilizer experiments, the application of compost at the rate of 2 and 4 tons per acre gave an average increase in yield, for a 17-year period, of 3.3 bushels per acre.

The plowing under of 3 tons of straw per acre with and without the application of 400 pounds of an 8-10-6 fertilizer, half applied with the straw and half with the seed, gave for straw alone an average increase of 4.5 bushels on alternately cropped, and 5.0 bushels on continuously cropped land, and for straw plus fertilizer 16.6 bushels on alternately cropped and 15.8 bushels on continuously cropped land.

In an experiment conducted in conjunction with a rotation in which rice was grown in alternate years on improved pasture land, the average increase in yield from an 8-10-6 formula applied at seeding time at the rate of 400 pounds per acre was for T. V. A. treble phosphate 14.4 bushels, for T. V. A. fused phosphate 13.4 bushels, and for bone meal 12.5 bushels per acre.

On continuously cropped land, ammonium sulphate and ammophos fertilizer, when applied at the rate of 400 pounds per acre with the seed and on the water 3 weeks after the land was submerged, gave no appreciable increase in yields, but when applied on the water 8 weeks after submergence, ammonium sulphate gave an average increase of 2.3, and ammophos 5.3 bushels per acre.

The application at seeding time of an 8-10-6 fertilizer on alternately cropped land, with phosphates from various sources, at the rate of 100, 200, and 300 pounds per acre, gave average increases for all sources of phosphate of 4.5, 4.1, and 6.0 bushels per acre from the 100, 200, and 300 pound rates. Fertilizers differing in formula were applied on the water 8 weeks after submergence at the rate of 100, 200, and 300 pounds per acre and for each rate of application the highest average yield was from the 8-10-6 formula. The average increase in yield from the application of 400 pounds of an 8-10-6 fertilizer with the seed was 2.2 bushels, and when half was applied with the seed and half on the water 8 weeks after the land was submerged, 9.1 bushels per acre. Various fertilizer combinations were applied with the seed at the rate of 200 pounds per acre, and the highest average yield was from the 8-10-6 formula.

In southwestern Louisiana, the general practice is to grow a rice crop, then use the land for cattle pasture for one or two years. Rice is the main cash crop with beef cattle a supplementary source of income. In permanent-pasture studies, the highest average yields of cured hay were from seeded improved pastures limed and fertilized.

LITERATURE CITED

(1) Beachell, H. M.
1943. Effect Of Photoperiod On Rice Varieties Grown In The Field.
Jour. Agr. Res. 66 (9):325-340.

(2) Chambliss, Charles E., and Jenkins, J. Mitchell.
1925. Experiments In Rice Production In Southwestern Louisiana.
U. S. Dept. Agr., Dept. Bul. 1356.

(3) Chambliss, Charles E., and Jenkins, J. Mitchell.
1923. Some New Varieties Of Rice.
U. S. Dept. Agr., Dept. Bul. 1127.

(4) Davis, Loren L., and Jones, Jenkin W.
1940. Fertilizer Experiments With Rice In California.
U. S. Dept. Agr., Tech. Bul. 718.

(5) Jenkins, J. Mitchell.
1936. Effect Of Date Of Seeding On The Length Of The Growing Period Of Rice.
La. Agr. Expt. Sta. Bul. 277.

(6) Jenkins, J. Mitchell.
1936. Permanent Pastures For Cattle Production In The Rice Area Of Southwestern Louisiana, La. Agr. Expt. Sta. Bul 276.

(7) Jones, Jenkins W., et al.
1941. Rice Varieties And Their Comparative Yields In The United States.
U. S. Dept. Agr., Cir. 612.

(8) Nelson, Martin.
1943. Rice Fertilization.
Ark. Agr. Expt. Sta. Bul. 430.

(9) Sturgis, M. B.
1934. Review Of Results On Fertilization For Rice,
La. Agr. Expt. Sta. (Unnumbered Pub.) 6 pp. (mimeographed.)

(10) Wyche, R. H.
1941. Fertilizers For Rice In Texas.
Tex. Agr. Expt. Sta. Bul. 602.